

*The Temperate and Alpine Floras of the Giant Volcanoes of Mexico.  
(Being a Report from the Committee on the Michaux Legacy.)*

*By Prof. Angelo Heilprin.*

*(Read before the American Philosophical Society, January 15, 1892.)*

Hemsley, in the fourth volume of his report on the botany of Mexico and Central America, enumerates 130 species of flowering plants, exclusive of sedges and grasses, which reach or pass beyond the 10,000-foot line on the slopes of the four principal volcanoes of the Mexican Republic—Orizaba, Popocatepetl, Ixtaccihuatl and the Nevado de Toluca.\* This enumeration is based mainly upon the data found on the labels of the various collections illustrating the region, and omits passing citations; it is thus, necessarily, to an extent incomplete, but yet it is an admirable survey of the general features of this upper flora. To Hemsley's list the following species enumerated by Liebmann as occurring on Orizaba can, I think, be safely added,† although possibly a few of the species require redetermination before their position or synonymy can be satisfactorily established.

	FEET.
Ranunculus Hookeri.....	10,000
Ranunculus llaveanus.....	10,000
Cerastium sp.?.....	14,000
Arenaria decussata.....	10,000
Arenaria leptophylla?.....	12,000
Oxalis latifolia.....	10,000
Trifolium amabile.....	10,000
Lupinus leptophyllus.....	10,000
Fragaria Mexicana.....	10,000
Potentilla sp.?.....	14,000
Alchemilla venusta.....	10,000
Alchemilla vulcanica.....	10,000
Alchemilla hirsuta.....	10,000
Echeveria mucronata.....	10,000
Sedum sp.?.....	10,000
Epilobium repens.....	10,000
Mentha sp.?.....	10,000
Gaura sp.?.....	10,000
Pimpinella sp.?.....	10,000
Dauca montana.....	10,000
Hydrocotyle Mexicana.....	10,000
Eryngium sp.?.....	14,000

\* "A Specimen of the Mountain Flora of South Mexico and Central America—Biologia Central-Americana," "Botany," iv, pp. 282-298, 1887.

† "Vegetation des Pika von Orizaba," *Botanische Zeitung*, 1844; also translated and abridged in Hemsley's Report, iv, pp. 145-150.

	FEET.
Sesseli sp.?	12,000
Ænanthe sp.?	12,000
Viburnum sp.?	10,000
Cornus sp.?	10,000
Stevia arbutifolia	12,000
Erigeron scaposus (Aster rivularis)	10,000
Bidens sp.?	10,000
Dahlia variabilis	10,000
Chrysanthemum (?) sagetum	10,000
Cnicus Jorullensis	10,000
Hieracium abscissum	10,000
Tagetes clandestina	10,000
Baccharis Jalapensis	10,000
Diodia sp.?	10,000
Gaultheria procumbens	10,000
Pernettya (Gaultheria) ciliata	14,000
Phacelia sp.?	14,000
Solanum stoloniferum	10,000
Lamourouxia Jalapensis	9,500
Pinguicula sp.?	10,000
Castilleja integrifolia	10,000
Castilleja scorzonerifolia	10,000
Castilleja sp.?	14,000
Verbena pulchella	10,000
Prunella vulgaris	10,000
Plantago Mexicana	10,000
Juniperus Mexicana	14,000
Govenia speciosa	9,500
Spiranthes sp.?	10,000
Serapias sp.?	10,000
Tigridia pavonia	10,000
Tillandsia sp.?	10,000
Bomarea hirtella	10,000
Agave sp.?	10,000

The approximate elevations as recorded by Liebmann are, with little doubt, given in French feet. This placing does not materially alter the positions of the plants in question. To Liebmann's list I would add the following, obtained by myself and my associates during a recent exploration of the Mexican volcanoes (1890):

	FEET.
Echeveria gibbiflora? (or E. secunda?) on Ixtaccihuatl	14,200
Ænothera tetraptera on Ixtaccihuatl and Popocatepetl	11,000-11,500
Symphoricarpus microphyllus on Popocatepetl	10,500
Lonicera filosa on Popocatepetl	10,500

	FEET.
Erigeron maximus on Popocatepetl.....	11,200
Baccharis concava on Popocatepetl.....	11,000
Gnaphalium oxyphyllum on Orizaba.....	13,500
Senecio salignus on Ixtaccihuatl.....	13,200
Arbutus spinulosus on Popocatepetl.....	10,500
Alnus castanæfolia on Popocatepetl.....	10,500
Draba aretoides (?) on Ixtaccihuatl.....	13,200

A number of other plants, such as Habenaria prasina, Platanthera nubigena, P. longifolia, Malaxis gracilis (among orchids), have been cited by Martens and Galeotti from the peak of Orizaba, so that the total list is brought close up to 200 species. I have in the table that follows appended the approximate elevations at which the plants occur, relying largely upon the data furnished by Hemsley. The letters that precede the names of the species have reference to the special mountain peak upon which the plants were found: O., Orizaba; P., Popocatepetl; I., Ixtaccihuatl, and T., Nevado de Toluca. The author wishes in this connection to express his indebtedness for various forms of assistance to Messrs. Thomas Meehan, John H. Redfield, Isaac Burk and Witmer Stone, members of the Academy of Natural Sciences.

	To 10,000 FEET.	10-12,000 FEET.	12-13,000 FEET.	13-15,000 FEET.
O. Ranunculus geoides.....		9-12,000		
O. R. Peruvianus.....			12,500	
O. R. Hookeri.....	10,000			
O. R. llaveanus.....	10,000			
O. R. sp.?.....				14,000
O. Nasturtium impatiens....		11-12,000		
O. " Orizabæ.....		12,000		
O. Draba myosotidioides....			12-13,000	
P. " Popocatepetlensis..		12,000		
T. " Tolucensis.....				8-14,000
I. " aretoides? (also O.)				13,200
O. Sisymbrium canescens....		12,000		
O. " Galeottianum..		8-11,000		
T. Erysimum macradenium..			12-13,000	
O. Viola ciliata.....	10,000			
O. " sp.?.....				14,000
T. Cerastium andinum.....			13,000	
O. " orthales.....		12,000		
O. " vulcanicum..		10-12,000		
O. " sp.?.....				14,000
O. Arenaria alsinoides.....		10-12,000		
O. " decussata.....	10,000			
O. " bryoides.....			12,500	

	To 10,000 FEET.	10-12,000 FEET.	12-13,000 FEET.	13-15,000 FEET.
T. <i>Arenaria bryoides</i> . . . . .				14-15,000
P. " " . . . . .		11,500		
O. " <i>leptophylla?</i> . . . . .		12,000		
O. <i>Colobanthus Quitensis</i> . . . . .		12,500		
O. <i>Oxalis latifolia</i> . . . . .	10,000			
T. <i>Geranium potentillæfolium</i> . . . . .	9-10,000			
O. <i>Trifolium amabile</i> . . . . .	10,000			
T. <i>Lupinus bimaculatus</i> . . . . .		12,000		
O. " <i>elegans</i> . . . . .	9-10,000			
O. " <i>glabellus</i> . . . . .	9-10,000			
P. " <i>Mexicanus</i> . . . . .		10-11,000		
T. " <i>montanus</i> . . . . .	9-10,000			
O. " <i>vaginatus</i> . . . . .		12,000		
P. " " . . . . .		12,000		
T. " " . . . . .		12,000		
I. " " . . . . .		12,000		
O. " <i>leptophyllus</i> . . . . .	10,000			
O. <i>Fragaria Mexicana</i> . . . . .	10,000			
O. <i>Spiræa discolor</i> . . . . .		10-12,000		
O. <i>Rubus trilobus</i> . . . . .	10,000			
O. <i>Potentilla ranunculoides</i> . . . . .		12,000		
O. " <i>Richardii</i> . . . . .			12,500	
O. " <i>sp.?</i> . . . . .				14,000
O. <i>Alchemilla orbiculata</i> . . . . .		12,000		
O. " <i>Sibbaldiæfolia</i> . . . . .		9-12,000		
O. " <i>venusta</i> . . . . .	10,000			
O. " <i>tripartita</i> . . . . .	10,000			
O. " <i>vulcanica</i> . . . . .	10,000			
O. " <i>hirsuta</i> . . . . .	10,000			
O. <i>Acæna elongata</i> . . . . .				14,000
O. <i>Heuchera Orizabensis</i> . . . . .			11-12,500	
P. <i>Ribes Jorullensis</i> . . . . .		10-12,000		
T. " " . . . . .		10-12,000		
O. " " . . . . .				13,500
O. <i>Echeveria mucronata</i> . . . . .	10,000			
I. " <i>gibbiflora?</i> (E. <i>secunda?</i> ) . . . . .				14,200
O. <i>Sedum sp.?</i> . . . . .	10,000			
P. <i>Oenothera tetraptera</i> . . . . .		11-12,000		
I. " " . . . . .		11-12,000		
O. <i>Epilobium repens</i> . . . . .	10,000			
O. <i>Mentha sp.?</i> . . . . .	10,000			
P. <i>Fuchsia microphylla</i> . . . . .	10,000			
O. " <i>mixta</i> . . . . .	10,000			

	To 10,000 FEET.	10-12,000 FEET.	12-13,000 FEET.	13-15,000 FEET.
O. <i>Gaura</i> sp.?	10,000			
O. <i>Lopezia hirsuta</i>	10,000			
O. <i>Microsechium ruderales</i>	9-10,000			
O. <i>Pimpinella</i> sp.?	10,000			
O. <i>Daucus montana</i>	10,000			
O. <i>Hydrocotyle Mexicana</i>	10,000			
O. <i>Eryngium eymosum</i>	8-10,000			
O. " <i>protæflorum</i>		12,000		
T. <i>Tauschia Coulteri</i>		10,500		
O. <i>Sesseli</i> sp.?		12,000		
O. <i>Enanthe</i> sp.?		12,000		
O. <i>Ottoa ænanthoides</i>		12,000		
O. <i>Peucedanum Tolucense</i>			12,500	
O. <i>Viburnum</i> sp.?	10,000			
O. <i>Cornus</i> sp.?	10,000			
O. <i>Abelia floribunda</i>	10,000			
P. <i>Symphoricarpus micro-</i> <i>phyllus</i>		10,500		
P. <i>Lonicera filosa</i>		10,500		
O. <i>Galium gemmiflorum</i>	10,000			
O. <i>Didymæa Mexicana</i>	10,000			
O. <i>Ageratum adscendens</i>		10-11,500		
O. " <i>arbutifolium</i>				13,500
P. " " "		11,000		
I. " " "				13,200
O. <i>Stevia monardiæfolia</i>		8-12,000		
O. " <i>arbutifolia</i>		13,000		
O. <i>Eupatorium adeno-chætum</i>	8-10,000			
O. " <i>grandidentatum</i>	10,000			
O. " <i>Orizabæ</i>		10-11,000		
O. <i>Haplopappus stoloniferus</i>		8-12,000		
O. <i>Chionolæna lavandulacea</i>			12,500-15,000	
I. " " "				13,300
O. <i>Gnaphalium oxyphyllum</i>				14,000
O. <i>Sabazia sarmentosa</i>		9-11,000		
O. <i>Achillea millefolium</i>	10,000			
P. <i>Baccharis concava</i>		11,000		
O. <i>Erigeron scaposus</i>	10,000			
P. " <i>maximus</i>		11,200		
O. <i>Senecio chrysactis</i>			12-13,000	
I. " " "				13,200
O. " <i>crystalloides</i>				14,000
P. " <i>Galeottii</i>		11,500		

	To 10,000 FEET.	10-12,000 FEET.	12-13,000 FEET.	13-15,000 FEET.
O. Senecia Galeottii.....		12,000		
O. " gerberæfolius ....				10-15,000
O. " helodes.....		11,500		
O. " multidentatus....			9-12,500	
O. " Orizabensis.....			10-12,500	
O. " procumbens.....				12-15,000
T. " "		10-11,000		
I. " salignus.....				13,200
O. Bidens sp.?.....	10,000			
O. Dahlia variabilis.....		10-11,000		
O. Chrysanthemum (?) sage- tum.....	10,000			
T. Cnicus nivalis.....		11,400		
O. " ".....				14,000
O. " Jorullensis.....	10,000			
P. Hieracium Mexicanum ...	10,000			
O. " abscissum ....	10,000			
O. " niveopappum .			13,000	
O. " thyrsoideum ..		12,000		
O. Tagetes clandestina.....	10,000			
O. Lobelia nana.....			11-12,500	
O. " Orizabæ.....	9-10,000			
O. Diodia sp.?.....		11,000		
O. Gaultheria procumbens..	10,000			
O. Arctostaphylos pungens..			12-12,500	
P. Arbutus spinulosus.....		10,500		
O. Pernettyia pilosa.....		9-12,000		
O. " ciliata.....				14,000
O. Pyrola Sartorii.....	9-10,000			
O. " secunda.....	8-10,000			
O. Chimaphila umbellata....	6-10,000			
O. Buddleia lanceolata.....	10,000			
O. Halenia alata.....	9-10,000			
O. " nudicaulis.....		9-12,000		
O. " nutans.....	9-10,000			
O. " paucifolia.....		9-12,000		
O. Polemonium grandiflora..		9-12,000		
O. Cobæa minor.....	10,000			
P. Phacelia pimpinelloides ..	10,000			
O. " " ..			12,500	
I. " " ..				13,200
O. Echinosperrum Mexica- num.....	10,000			
O. Lithosperrum distichum.		11-12,000		

	To 10,000 FEET.	10-12,000 FEET.	12-13,000 FEET.	13-15,000 FEET.
O. <i>Solanum verrucosum</i> . . . .		10-12,000		
O. " <i>stoloniferum</i> ? . . .	10,000			
O. <i>Saracha umbellata</i> . . . . .	10,000			
O. <i>Lamourouxia Jalapensis</i> . .	9,500			
O. <i>Pinguicula</i> sp.? . . . . .	10,000			
O. <i>Calceolaria Mexicana</i> . . . .	10,000			
O. <i>Pentstemon gentianoides</i> .		9-12,000		
O. <i>Mimulus glabratus</i> . . . . .			12-12,500	
O. " <i>Orizabæ</i> . . . . .		10-12,000		
O. <i>Veronica serpyllifolia</i> . . . .				14,000
O. <i>Castilleja lithospermoides</i> .		12,000		
O. " <i>pectinata</i> . . . . .		10-12,000		
O. " <i>Tolucensis</i> . . . . .				13,200
T. " " . . . . .				14,200
O. " <i>integrifolia</i> . . . . .	10,000			
O. " <i>scorzonerifolia</i> . . . . .	10,000			
O. <i>Pedicularis Orizabæ</i> . . . . .		12,000		
O. <i>Verbena teucrifolia</i> . . . . .		10,500		
O. " <i>pulchella</i> . . . . .	10,000			
O. <i>Salvia biserrata</i> . . . . .		9-10,500		
O. <i>Scutellaria cœrulea</i> . . . . .	9-10,000			
O. <i>Stachys repens</i> . . . . .		9-11,000		
O. <i>Prunella vulgaris</i> . . . . .	10,000			
O. <i>Plantago Mexicana</i> . . . . .	10,000			
O. <i>Peperomia Lindeniana</i> . . . .	10,000			
O. <i>Persea Orizabæ</i> . . . . .		7-10,500		
O. <i>Arcenthobium campylopo-</i> <i>dum</i> . . . . .		10-11,000		
O. " <i>cryptopo-</i> <i>dum</i> . . . . .		10-11,000		
O. " <i>oxycedri</i> . . . . .		12,000		
O. <i>Euphorbia Orizabæ</i> . . . . .	8-10,000			
O. <i>Urtica chamædryoides</i> . . . .	10,000			
O. " <i>spiralis</i> . . . . .	10,000			
O. <i>Pilea vulcanica</i> . . . . .	10,000			
O. <i>Parictaria Pennsylvanica</i> . .	10,000			
O. <i>Alnus acuminata</i> . . . . .	7-10,000			
O. " <i>Jorullensis</i> . . . . .		12,000		
P. " <i>castanifolia</i> . . . . .		10,500		
O. <i>Quercus floccosa</i> . . . . .	8-10,000			
O. " <i>glabrescens</i> . . . . .	8-10,000			
O. " <i>Orizabæ</i> . . . . .	8-10,000			
O. " <i>reticulata</i> . . . . .	8-10,000			
O. <i>Salix cana</i> . . . . .		11-12,000		

	To 10,000 FEET.	10-12,000 FEET.	12-13,000 FEET.	13-15,000 FEET.
O. <i>Salix latifolia</i> .....		12,000		
P. " <i>paradoxa?</i> .....		10,500		
O. <i>Juniperus tetragona</i> .....				12-14,000
O. " <i>Mexicana</i> .....				14,000
P. " " .....		11,500		
P. <i>Pinus ayacahuite</i> .....		11-12,000		
O. " " .....				13,500
P. " <i>Hartwegii</i> .....				13-14,000
O. " <i>Montezumæ</i> (also P. & I.) .....				10-14,000
O. " <i>patula</i> .....		10-12,000		
O. <i>Abies religiosa</i> (also P. & I.) .....		12,000		
O. <i>Govenia speciosa</i> .....	9,500			
O. <i>Habenaria vulcanica</i> ....		10-12,000		
O. " <i>prasina</i> .....			12,800	
O. <i>Platanthera nubigena</i> ....			12,500	
O. " <i>longifolia</i> ....			12,500	
O. <i>Malaxis gracilis</i> ... ..			12,500	
O. <i>Spiranthes ochracea</i> .....			12,500	
O. <i>Serapias</i> sp.? .....	10,000			
O. <i>Tigridia pavonia</i> .....	10,000			
O. <i>Tillandsia</i> sp.? .....	10,000			
O. <i>Sisyrinchium scabrum</i> ....	10,000			
O. <i>Bomarea acutifolia</i> .....	7-10,000			
O. " <i>hirtella</i> .....	10,000			
O. <i>Agave</i> sp.? .....	10,000			
O. <i>Echeandra terniflora</i> .....		11,000		
O. <i>Allium glandulosum</i> .....		9-12,000		
O. <i>Stenanthium frigidum</i> ....			9-12,500	

From the preceding it will appear that, exclusive of grasses and sedges, there are approximately :

	FEET.
5 species which pass beyond .....	14,000
28 " " " " .....	13,000
46 " " " " .....	12,000
97 " " " " .....	11,000
115 " " " " .....	10,000
199 " " about reach or pass beyond .....	10,000

By far the greater number of the species enumerated in the preceding list are cited from the Citlaltepel (the "Star Mountain"), or Peak of Orizaba, as it is commonly known, which, from the specially favorable conditions surrounding its position, has attracted the attention of botanists more than any other mountain of Mexico. With its base buried in the



luxuriant forests of the eastern *tierra caliente*, it presents an unbroken botanical front to the line of perpetual snow, 15,000 feet above the sea, and thus exhibits in beautiful sequence the different vegetal zones which climate more particularly has marked out. There is probably no other mountain in the world which so thoroughly presents the essentials of a study of mountain floras as Orizaba; the luxuriance of growth at its base, the high level to which the forest zone attains, and the isolation, due to volcanic structure, of the peak itself, are the specially distinguishing features of this summit. So far as the temperate and alpine floras of the other giant mountains of Mexico are concerned—Popocatepetl, Ixtaccihuatl and the Nevado de Toluca—there is no question that they are very closely related to the similar floras of the Star Mountain, as indeed it would naturally be expected they would be. Of this correspondence I have satisfied myself through a personal examination of the floras *in situ*; unfortunately, the conditions attending the ascent of these mountains were such as to prevent us from making more than “sample” collections, but they illustrate in a broad way the general features of the vegetation. All four summits rise from the table land through a zone of pine forest. On the western slope of Orizaba, or towards the town of San Andres Chalehicomula, we found the pines, with *Pinus Montezumæ* (var. *macrophylla*—the common long-leaved species), *P. Teocote* and *P. pseudostrobus*, to begin as a distinct zone, at an elevation of some 9000 feet, occupying nearly the same position on the western slopes of Popocatepetl and Toluca; on Ixtaccihuatl the line descends approximately 500 feet lower. There can be little question, it appears to me, that the limitation downward in these special cases is not so much dependent upon climatic conditions as it is upon certain physical peculiarities of the surroundings and the artificial means that have been resorted to for the removal of the native growth. The vast accumulation of ash and dust-sand which to-day envelopes the plateau base of the mountain, deposited as a disintegration downwash from above or as a wind sediment from below, lends itself at best to the development of but a scant vegetation; large areas are wholly barren, while others are redeemed only by a withered and scattered growth of grass and insignificant herbs. Over these lower areas trees are but distant ornaments. That this limitation of 9000 feet is not the actual or natural boundary of the pine zone is shown by the condition of the eastern face of the mountain, which descends from the plateau, or by the face of the plateau itself. Thus, on the hills about the town of Orizaba, at an elevation of some 4800 feet, we observed *Pinus pseudostrobus*—a form closely related to *P. Montezumæ*, and also entering into the composition of the lower pine woods of the Citlaltepétl—growing in great profusion; and on the steep southern face of the plateau descending to the volcano of Jorullo, we followed *Pinus Montezumæ* or *P. occidentalis* to the level of 4000 feet, or perhaps even lower—far below the upper level which the palms attain in certain parts of Mexico.\*

\* We observed a palmetto-like form, probably a *Brahea*, growing abundantly on the

The extended vertical distribution of the pines is very remarkable, not less so than the abrupt limitation southwards of the genus. If the identification of the common form of British Honduras and of Cuba (*Pinus Cubensis*) with *P. Montezumæ* (*P. occidentalis*) be considered correct—for which, however, there appears to be considerable doubt—and similarly, the identification of this last with the species (or one of the species) growing in the upper vegetal zone of Orizaba, etc., then the range of a single species is made coincident with that of the entire genus—indeed, so far as the western hemisphere is concerned, with that of the entire family or tribe. Nor is there, probably, another instance known of a perennial having an equivalent range of 14,000 feet, or upwards of two and a half miles.\* Humboldt places the lower limit of *P. Montezumæ* in Mexico at 4092 feet (at very nearly the position in which I found it below Buena Vista on the road connecting Ario de Rosales with the hacienda of La Playa, base of Jorullo), and its upper limit, as determined by him on the Cofre di Perote, at 12,936 feet.† Liebmann places the upper limit, on the northwestern side of the Peak of Orizaba, still higher, or at about 14,000 feet.‡ I am not certain that we observed, whether on Orizaba, Popocatepetl, or Ixtaccihuatl, the common “long-leaved Mexican pine” at anything like this elevation; certain it is that while this species enters, with the *P. Teocote* and *P. pseudostrobus*, very largely into the formation of the lower pine woods of the mountains in question, at elevations of from 9000 to 11,000 feet or thereabouts, it is distinctly succeeded in the upper zone by the very common short-leaved form (*Pinus Ayacahuite*) and *P. Hartwegii*. That these various forms have been repeatedly interchanged by botanists and travelers is positive; nor, indeed, in the present uncertainty regarding the species of Mexican pines, would it be safe to assert that all these species are really distinct. We also found the upper limit of the pines on Orizaba to be close on the 14,000-foot line, but on the adjacent Sierra Negra, which faces the peak of Orizaba on the south, the tree line appears to rise fully two or three hundred feet higher. As Liebmann observes, the trees become in a measure dwarfed, though never shrubby or prostrate. At an elevation of 13,200 feet, where they

limestone mountains west of Yautepec (on the ridge separating that town from Cuernavaca), at an altitude of 6500 feet; the same species appears still higher, 7000–7500 feet, on the similar calcareous soil of the region about (north of) Tehuacan. At both localities the palm, together with the Viznaga (*Viznaga mammillaris*), and the organ cactus, forms the predominant feature of the vegetation; the stem rises to some 30–35 feet. Liebmann states that *Corypha* and *Chamærops* are both found on the highlands of Mexico at an elevation of 8000 feet. Hemsley is probably correct in referring one of these forms to *Brahea*; the other may be a *Chamædorea*, but it seems to me more likely to be a true *Sabal*. Drude has, perhaps, doubted the accuracy of Liebmann's observations, since he makes no mention of any Mexican palm rising above 5000 feet (“Die Geographische Verbreitung der Palmen,” in “Petermann's Mittheilungen,” 1878: “Handbuch der Pflanzengeographie,” 1890).

\*The Oregon pine or Douglas fir (*Pseudotsuga Douglasii*) extends its habitat from the sea level on the Pacific coast to an elevation of nearly 10,000 feet in Colorado.

†“Views of Nature,” Bohn's edition, p. 315.

‡If French feet, then more nearly 15,000 feet.

still formed groves or thickets, they rose to a height of certainly not less than 30-40 feet. Roezl, as quoted by De Candolle (Parlatore, in the "Prodromus," xvi, ii, p. 400), and Hemsley give, it appears to me, too great an elevation for the pines on Popocatepetl and Ixtaccihuatl, 13-14,000 feet; the first figure more nearly represents the true limitation. Felix and Lenk \* delimit the zone on Popocatepetl at about 250 feet above the ranch of Tlamacas, or, according to their statement, at almost exactly 13,000 feet; my own observations place the line somewhat higher, 13,160 feet †—or about 100 feet lower than the point where we met with the last pines on Ixtaccihuatl.

At no other point on the earth's surface do the pines attain such an extreme elevation as on the Mexican volcanoes; indeed, if we except the *Juniperus fetidissima* found by Thomson in the Spiti Valley, Himalayas, at an altitude of 15,000 feet, the entire group of the Coniferae almost everywhere falls far below this line. Barring exceptional cases, the uppermost trees on the Himalaya, as in north temperate regions generally, are conifers, but these virtually cease at an elevation of some 12,000 feet, ‡ although flowering plants continue for still 7000 feet higher. On Mt. Ararat, according to Drude, the uppermost trees are birches, poplars and willows, and not conifers, § the tree line on the northwestern face of that mountain being situated somewhat below 8400 feet. On the extinct volcanic summit of the San Francisco mountain (Northcentral Arizona, lat. 35° 20'), with an elevation of 12,794 feet, Hart Merriam found the timber line at approximately 11,500 feet, marked by the disappearance of the fox-tail pine (*Pinus aristata*) and Engelmann's spruce (*Picea Engelmanni*). A somewhat higher level is, perhaps, reached by the balsam (*Abies subalpina*) in Colorado—12,000 feet. ||

The point of most interest that suggests itself in connection with the distribution of the Mexican pines is the distinctness of the forms from those occurring in the region lying to the north. With barely an exception ¶ all the species occurring on the lofty volcanoes are endemic to the Mexican (Central-American) region, and are consequently not found in the pine tracts of the Rocky Mountain system. In view of the longitudinal

\* "Beiträge zur Geologie und Paläontologie der Republik Mexico," p. 20, 1890.

† It is interesting to note in this connection that Von Gerolt, who made the ascent of Popocatepetl in 1833, places the *limit of vegetation* on that mountain at 12,614 (English) feet, not including "a mossy plant, *Arenaria bryoides*, which is occasionally found some hundred feet higher." Egloffstein, "Geology and Physical Geography of Mexico," 1864, p. 25.

‡ Schlagintweit observed the last groups or "woods" of these trees at an elevation of 11,800 feet, although cultivated specimens of *Populus Euphratica*, grown in the gardens of the monastery of Mánguang, were found nearly 2000 feet higher, at 13,400 feet ("Sitzungsber. Münch. Akad.," 1865, I, p. 238). This investigator places the limit of Phanerogams on the Gushaukar Peak (lat. 31° 23', long. 80° 18') at 19,237 feet (*op. cit.*, 1867, p. 416; also in "Results of a Scientific Mission to India and High Asia").

§ "Handbuch der Pflanzengeographie," p. 402.

¶ C. H. Sargent, "The Woods of the United States," p. 132, 1885.

‡ *Pinus cembroides* ranges into the Santa Catalina mountains of Arizona (3500 feet elevation).

direction of these mountains and the fact that they are continued by a plateau system of elevations of from 6000–8000 feet into the very heart of the volcanic area, this circumstance appears a little remarkable; its explanation is possibly to be sought in the same series of conditions which have determined the endemic character of the alpine flora generally of the Mexican and South American summits. In the case of such hardy perennials as the pines, however, it is more difficult to account for the anomaly than in that of the seemingly much more pliable herbaceous plants, which are commonly assumed to lend themselves more readily to changes or modifications as the result of alterations in the physical conditions of their surroundings. The comparatively recent origin of the Mexican volcanoes proves that the floras which they carry must be of equally recent date; it follows, therefore, as a corollary that if the components of these floras are derivatives from preëxisting floras still extant, such modifications of structure as they have undergone must have been rapid in their formation—more rapid, probably, than is generally allowed for modifications of this kind. Can it, perhaps, be assumed that the special characteristics and conditions which belong to elevated volcanic cones are conducive to rapid change? It is true that not all the volcanic summits of Mexico are of equivalent age, and it can probably be assumed that some are of even considerably greater age than others (although possibly belonging to the same period of geological time); thus the worn-off and effaced summit of the Ixtaccihuatl, without doubt, long antedates such perfect cones as Orizaba and Popocatepetl; and the serrated ridges of the Ajusco, or their continuations, bear a similar relation to the series of more or less perfect cones and bosses which are distributed over the plateau north of the line occupied by them. Possibly the existing flora was first developed on such ancient slopes, whence by a gradual transference it gained the position which it now holds (largely modified and altered in form).

It must be admitted, however, that our knowledge on these points is still so limited that it can scarcely originate more than speculation or surmise; it no more explains the present problem than it answers the question: Why are the pines limited to the northern hemisphere—or more definitely, why the North American pines cease so abruptly in Nicaragua? What are the special conditions which prevent them from spreading further southward, and why is the upper zone of the Andes destitute of these trees? Indeed, the endemic character of the Mexican conifers and the absence of their immediate representative in South America might suggest to some an origination wholly independent of a true North American stock—an origination suggestive of a former Atlantis. The presence of pines in some of the West Indian islands—Cuba, Jamaica, Santo Domingo, and again in the Canary Islands\*—might, moreover, be taken in evidence of a trans-Atlantic land connection having actually

\* *Pinus Canariensis*, the last of the three-leaved pines from the western region of the Old World.

existed at a comparatively modern period. Botanists have, indeed, long since pointed out the relation existing between the modern coniferous flora of North America and the equivalent Miocene flora of Europe—a relationship which might almost be considered an equivalency—and have even hinted at the possible derivation of the one from the other.\*

The singular distribution of the pines makes it certain that neither their vertical nor their horizontal (or longitudinal) range is determined by conditions of temperature alone, or, perhaps, even primarily. Humboldt has plainly stated this fact: "This absence from the southern hemisphere of the true Abietinæ, of the Juniperinæ, Cupressinæ and all the Taxodineæ, as likewise of the *Torreya*, of the *Salisburia adiantifolia*, and of the *Cephalotaxus* among the Taxinæ, vividly reminds us of the enigmatical and still obscure conditions which determined the original distribution of vegetable forms. This distribution can by no means be satisfactorily explained, either by the similarity or diversity of the soil, by thermal relations, or by meteorological conditions." † Mr. Thomas Meehan has repeatedly insisted that the timber line on mountains is not essentially a fixture determined by climate, but depending more particularly upon special topographic features of the surroundings—the character of the soil, amount of downwash, exposure to storms, etc. The critical comparison of different timber lines, taken in conjunction with vertical distribution, shows that this contention is at least largely true. The abrupt termination of the forest on some of our mountain heights, whether high or low—as for example on the Rocky Mountains or on Mt. Katahdin—and the continuance of trees of still noble proportions practically to the very limits of disappearance, point very strongly to this conclusion, a conclusion which is further supported by the reappearance in many places (of the same region) of the identical forest in positions considerably more elevated (and presumably much better adapted to a special development). The irregular height to which the "Waldregion" attains on the Alps and on other mountains of Southcentral Europe is certainly attributable at least as much to topographic (physiographic) as to climatic conditions. Thus, on the main body of the Central Alps (46°–47° N. lat.), the limit of trees is found at approximately 6400 feet; in the Southern Alps of Dauphiné (45° N. lat.), at 8200 feet (in places only 5550 feet); on the Illyrian Alps, of Karst, Austria (46° N. lat.), at 5000 feet, and on the Dinaric Alps of Bosnia (44° N. lat.), at 5300 feet. So, again, on the Jura mountains, in lat. 47°, this limit is reached at 4900 feet, whereas on the Altai, in lat. 50°, it rises nearly 1500 feet higher, or to 6400 feet. ‡

The limitation to height of herbaceous plants parallels the history presented by trees. It is generally assumed in their case that the line of

\* Hildebrand, "Die Verbreitung der Coniferen," "Verhandl. d. natur. Vereines der preuss. Rheinlande und Westphalens," xviii, p. 377, 1861.

† "Physiognomy of Plants," in "Views of Nature," p. 321, Hohn edition, 1850.

‡ Grisebach, "Vegetation der Erde," I, pp. 180 *et seq.*, 1884.

perpetual snow is the determinant of absolute or greatest elevation, but this is not strictly the case. Thus, it is well known that in the Swiss Alps phanerogamic plants are found nearly 2700 feet above the snow line; the beautiful mountain pink (*Silene acaulis*) has been met with at an elevation of 11,382 feet,\* and *Androsace glacialis*, a primulaceous plant, at 11,406 feet, on the Piz Linard (Grisons). Indeed, Heer has determined not less than a hundred species (or approximately that number) of flowering plants (representing twenty-three families) as growing on the Rhaetic Alps above the snow line (9060 feet), and Martius has recorded twenty-four species from the Grands Mulets, Mont Blanc, on elevations ranging from 10,540 to 11,300 feet.†

So far as the Mexican summits are concerned, I think it may be safely asserted that the tree or timber line is not an absolute one; in other words it is not one which is determined by the natural conditions of growth of the plant itself, but rather it is dependent upon purely local causes. It is scarcely conceivable, for example, that on Orazaba, where at an elevation of upwards of 13,200 feet the trees were still 30-40 feet in height, an additional 500-600 feet should so materially alter favorable (climatic) conditions of growth into unfavorable ones as to produce extermination; indeed, we must assume that this change is even much more rapid, for at the very verge of the timber line the pines, although necessarily harboring a considerable number of small specimens, still easily measured 20-30 feet. This condition we found repeated on Popocatepetl and Ixtaccihuatl, most markedly, perhaps, on the latter mountain; I am positive that some of the uppermost pines here, very close to the disappearing line, were not less than 40-50 feet high, if not higher. Again, on Popocatepetl, as has already been remarked, the timber line ceases a little above 13,100 feet, the trees themselves being of rather inconsiderable height. On an equivalent height on a spur of the Sierra Tlamacas,‡ however, the pines are still noble foresters, and on the Sierra Tlamacas itself, off in the direction of Ixtaccihuatl, they rise to elevations several hundred feet higher. There is little doubt in my mind that the actual limitation on the summits here referred to is mainly determined by such physiographic conditions as steepness of slope, downwash of soil, exposure to the cold waters of melting snows, storms, etc. How much higher, under more favorable conditions, the tree line might have attained, I am unable to say; but it is interesting to note that such as it is, it is virtually the most elevated tree line in the world. §

\* Humboldt, "Views of Nature," p. 318. I met with this plant (summer of 1891) in various parts of Greenland, between lat. 69° and 77° 40', growing from the sea-level to an elevation of 1500-2000 feet.

† Grisebach, *op. cit.*, i, p. 167.

‡ Crossed just before reaching the ranch of Tlamacas.

§ This statement, perhaps, requires modification. Pöppig, from manuscript data submitted to him by Engineer Benjamin Scott, asserts ("Reise in Chile, Peru and auf dem Amazonenstrome," ii, p. 80) that on the Peruvian Andes, near the hamlets of Huaylillas de Potosi and Uchusuma, treelets of (?) *Potylepis racemosa* are found at elevations of 15,883

In the north temperate regions the timber line, where marked by the disappearance of conifers at all, seems to characterize indiscriminately the zone either of pines or firs (spruces); probably in the greater number of instances the latter are the most far-reaching trees. In the Harz mountains, the Riesengebirge, the Böhmerwald, the Jura mountains, and in many parts of the Alps, Carpathians and Pyrenees the firs are the delimiting zone of forest; but again, in other parts of the Alps and Pyrenees, in the Tatra (Central Carpathians), the Altai, and on many of the mountain crests of the Mediterranean region, the pines (notably *Pinus cembra*) considerably overtop the firs, even if they do not form that distinct vegetal zone which is constituted by the latter. In North America, perhaps even more than in Eurasia, do the firs constitute the uppermost coniferous zone, a zone which is so eminently defined on the higher elevations of the Appalachian system of mountains (White mountains, Black mountains of North Carolina). In the Rocky mountains the pines and firs both attain the timber line, but the latter predominate by far as a zone-making element; indeed, on many of the more elevated summits the pines only sporadically mingle in with firs. It is the more interesting, therefore, to find that on the still higher summits of Mexico the reverse order obtains. The zone of firs (consisting of *Abies religiosa*), as I had occasion to observe on Orizaba, Popocatepetl, Ixtaccihuatl and the Nevado de Toluca, virtually ceases at about 11,500-12,000 feet,\* or two thousand

and 15,912 feet, or nearly 150 feet higher than the *Saxifraga Boussingaultii*, from the slopes of Chimborazo, which Humboldt considered to be "the highest growing phanerogamic plant in the world" ("Views of Nature," p. 234). Again, Humboldt himself observed occasional specimens of tree-like *Verbesina* on Pichincha at an elevation of nearly 14,400 feet ("Kleinere Schriften," p. 57). It seems likely that the measurements of altitude in both of these cases are given too high a value; at any rate, the more recent surveys of the Andean summits have, in nearly all cases, tended to diminish rather than to increase the formerly accepted measurements. Raimondy reports *Sambucus Peruviana* and *Polylepis racemosa* from an elevation of 14,390 feet on the Peruvian Andes; *Polylepis tomentella* was observed by Weddell at 14,710 feet, and *P. lanuginosa*, by Jameson, on Chimborazo, at 13,965 feet. Most of these upper trees are dwarfed, scarcely attaining more than a few feet in height, and, indeed, the actual timber line falls considerably below the elevations here given. Humboldt makes the interesting observation that in the region about Quito trees 45-60 feet in height are rarely met with above some 8800 feet. At Chicha, on the Peruvian Andes (13° degrees south of the Equator), at an elevation of 12,200 feet, Ball observed but a single tree, *Sambucus Peruviana*, a form closely related to the common black elder of Europe ("Notes of a Naturalist in South America," p. 101, 1887). In remarkable contrast to these cases of special elevation is the condition of the forest vegetation on Kilima Njaro, on approximately the third degree of south latitude. According to Dr. Hans Meyer, the "average limit of the forest belt is about 9500, the extreme limit imposed by the climatic conditions being some six or seven hundred feet higher" ("Across East African Glaciers," p. 132, 1891); phanerogamic plants are, however, found on the same mountain up to 15,420 feet (*op cit.*, p. 167). In the Sunda Islands (Java, Sumatra, Borneo), which lie almost under the Equator, as is well known, the timber line also falls below 10,000 feet, although individual mountain summits rise 2000 and 3500 feet higher.

\* We met with the last spruces on Ixtaccihuatl at approximately 11,500 feet; the lowest were found at about 9200 feet, or very nearly 1000 feet lower than we observed them on the peak of Orizaba. I have no doubt that the species in question is found at

feet below the line of the pines, and yet more below that of the last junipers.\*

We observed the last specimens of this genus (*Juniperus tetragona*) covering the bare rocks of Orizaba at some little distance beyond the actual tree line. It is not always easy to determine just what are the causes which operate towards establishing and regulating the succession of special vegetal zones on mountain slopes any more than it is possible, in our present knowledge, to explain the anomalies of succession on the horizontal plain stretching towards the Pole. The law of parallelism in horizontal and vertical succession, which Humboldt first formulated, and which was founded on the perception of climatic influences almost alone, while it touches the broader aspects of the problem, does not essentially explain the detail; nor can it be said that the modification of this law, defined by an excess or decrease of solar illumination, the horizontality or verticality of the solar rays, etc. (as elaborated by Wahlenberg, Grisebach and others), any more explains the special contradictory features of this distribution. Preoccupation or first possession of a region by a special group of plants has doubtless much to do with the problem; it is an important factor towards determining supremacy, and must, therefore, largely regulate the outcome from a competitive struggle for existence.

The oaks of the Mexican volcanoes occupy the lower pine belt, ranging to about 10,000 feet. We obtained three species on Orizaba—*Quercus reticulata*, *Q. Orizabæ*, and a third form which we have not yet been able to identify. Above 8000 feet they are comparatively rare and no longer form forests, such as are to be met with in the lower region of 4000–6000 feet. In the more or less open dustcountry below the pines—*i. e.*, below where the pines appear on the western slope of Orizaba, about 9000 feet—they are still fairly abundant, forming groves and copses, but once entering the pines they appear only as stragglers. The same condition prevails on Popocatepetl and Ixtaccihuatl. Associated with the oaks are one or more species of alder, *Alnus Jorullensis* and *A. castanifolia*; we found the former a tree of some 15–20 feet height, extending up to 12,000 feet or more. The second form, which is now generally looked upon only as a variety of *A. Jorullensis*, and which we found on Popocatepetl at an elevation of about 11,000 feet, is a member of the flora of the Peruvian Andes—one of the very few plants which are common to the two regions.

As regards the non-arboreal vegetation of the Mexican summits, the list of species given at the beginning of this paper sufficiently illustrates

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a very much lower altitude than where we actually observed it; indeed, it appears that Humboldt and Boupland met with it not far from the forest of Chilpanzingo, south of the Mexican plateau, at an elevation of barely more than 4000 feet.

\*It is true that Schiede mentions the tree as rising to the timber line on Orizaba (Parlatore, in De Candolle's "Prodromus"), but I believe the statement to be erroneous. Galeotti's observations, which accord almost exactly with my own, place its limit at some 12,200 feet. Hemsley, on the other hand, reduces the elevation to 10,500 feet, a figure which is 1500 feet too low.



its character. A few remarks from personal observation may not, however, be amiss. We found the most varied flora—*i. e.*, in the region above 8000 feet—on Popocatepetl, and it was here, too, that the vegetation presented itself in its most luxuriant aspect.\* Taking the physiognomy of the four summits into one general consideration, it may be said that the most noticeable or distinctive plants are two or more species of *Senecio* and a lupine (*Lupinus vaginatus*). The yellow flowers of the former and the blue of the latter were an ornament to the vegetation almost everywhere between 10,000 and 12,000 or 13,000 feet. *Senecio chrysactis*, a graceful plant 3-4 feet in height, reaches the limit of pines on all four of the loftiest summits, rising somewhat higher, seemingly, than *S. Galeottii*.

These yellow "asters," with the tall lupine, form a compact undergrowth to the upland pines, especially where the latter have been in one way or another thinned into groves, leaving patches of open country in their midst. In such localities the vegetation is truly luxuriant, and the eye is charmed by the brilliancy of color which is everywhere manifest. The horseman traverses a flowering prairie with his animal buried to its flanks in the rank growth; on Popocatepetl, more particularly, is this the case. Above 13,000 feet we found the greatest number of species in flower on Ixtaccihuatl. Here, immediately about our night's camping ground, at an elevation of approximately 13,200 feet, we found a veritable garden. The ground was decked with a profusion of the blood-red *Castilleja Toluensis*, the carmine *Echeverria gibbiflora* (or *E. secunda*?) and the yellow *Ageratum arbutifolium*, while from the rock-fissures protruded tufts of *Asplenium trichomanes* (var. *majus*)—the only fern we were fortunate enough to secure for our collections—and partially concealed masses of *Chionolena lavandula*, *Phacelia pimpinelloides*, etc. The moisture which here accumulates from the melting snows combines with a favorable position and exposure to sunlight towards a specially luxuriant growth. At the base of the boulder mass which marks the last stage in the ascent of the Nevado de Toluca—consequently at an altitude of 14,200 feet—we found the ground similarly carpeted with flowers, noticeably so with clumps of *Castilleja Toluensis*, but at this elevation the general aspect of the region was far less cheerful and inviting than on Ixtaccihuatl. There was little or no grass or moss, and the *Castillejas* and *Echeverrias* merely occupied sand spots between the lichen-covered rock débris. The last flowers to disappear on Orizaba, so far as our own observations extended, were the *Castilleja*, already mentioned, and a *Draba* (*D. aretoides* or *D. Popocatepetlensis*), both of which follow close to the snow line, or very nearly to 15,000 feet—possibly even above this point. The last-named plant was also found on Popocatepetl and Ixtaccihuatl, but at a somewhat lower level (13,000-13,200 feet).

\* I have no doubt that the eastern face of Orizaba—the side from which Liebmann and Galeotti made their ascents—is much more prolific in plant life than the one turned towards the dry and dusty table-land (the side of San Andres Chalchicomula), whence our party scaled the summit.

Among the more distinctive vegetal features of the lower volcanic slopes may be cited the dense bushes or thickets of *Arbutus spinulosa* and (the rigid) *Symphoricarpus microphyllus*, which border the rough mule-ways for long distances at (approximately) the 11,000-foot level, characterizing there a partial zone of their own. We found the ericaceous plants particularly abundant on Popocatepetl. With them is associated the magnificent red-flowering honeysuckle (*Lonicera filosa*), a stately plant 4-6 feet in height, which is certainly one of the most attractive growths of the region. To this zone succeeds a belt of composites, characterized by a special development of *Baccharis concava* and *Erigeron maximus*. It need hardly be said that the zonal lines—if, indeed, they are really worthy of such characterization—are not well differentiated; the plants of different belts mix in well with one another, so that everywhere there is considerable overlap. Nor do the same plants always occupy the same positions on the different mountains. Still, an approximation to zonal separation is to an extent manifest, especially where the maximal development of any series of plants is reached.

One of the most beautiful plants of the roadside, most abundant, perhaps, between 11,000 and 12,000 feet, is a pink evening primrose (probably *Enothera tetraptera*) with flowers somewhat smaller than those of a rose; the plant can, indeed, be appropriately designated the "alpine rose" of the Mexican mountains, as it is not unlike in general appearance a wild rose, though provided with only four petals. Its showy blossoms constitute one of the glories of the mountain roadways, but it is not entirely absent from favored open spots of the lower regions. We met with the plant abundantly in the meadows about Patzcuaro, at an elevation barely exceeding 7000 feet. Here it was associated with *Jussiaea repens*, *Cuphea procumbens*, *Sisyrinchium micranthum* (?), *Baccharis conferta*, etc.

The preponderating element in the upper Mexican flora is made up of forms which distinctly represent the temperate and Arctic regions, and not of modifications (suited to a more rigorous climate) of the lower or basal floras of the same region. This is the condition which is found to characterize the high mountain floras of tropical regions generally, as distinguished from those of temperate climes, and for reasons which have been well pointed out by Engler in his exhaustive treatment on the development of the vegetable world.\* Most of the Mexican plants occurring above 10,000 feet, while they are to a very great extent congeneric with the forms of temperate North America, are specifically almost wholly distinct. Indeed, the relationship with the plants of the much more distant Andean summits, so far as the recurrence of identical specific forms is concerned, appears to be considerably more intimate than it is with the forms belonging to the north. The reason for this is to me at the present time entirely conjectural.

\* "Versuch einer Entwicklungsgeschichte der Pflanzenwelt," II, 1882.

The following species are found on the Andean summits from New Grenada to Peru or Bolivia :

- Ranunculus Peruvianus.  
 Sisymbrium canescens.  
 Cerastium Andinum.  
 Arenaria alsinoides.  
 Colobanthus Quitensis.  
 Trifolium amabile.  
 Alchemilla orbiculata.  
     "    Sibbaldiæfolia.  
     "    tripartita.  
     "    hirsuta.  
 Acæna elongata.  
 Ottoa ænanthoides.  
 Tauschia nudicaulis.  
 Lobelia nana.  
 Halenia elata.  
 Saracha umbellata.  
 Mimulus glabratus.  
 Veronica serpyllifolia.  
 Alnus acuminata.  
     "    Jorullensis.  
 Sisyrinchium scabrum.

—about ten per cent. of the entire flora. In view of the distance which separates the two regions—some 900 to 2400 miles—this is, after all, not such a small number ; indeed, the wonder is rather that so many alpine forms should have found it possible, in the region of the tropics, to cross the depression of the Isthmus of Panama.

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*Observations on the Chinantec Language of Mexico.*

*By Daniel G. Brinton, M.D.*

(Read before the American Philosophical Society, January 15, 1892.)

*Name.*—The folk-name *Chinanteca*, plural of *chinantecatl*, is a word in the Nahuatl language meaning, "inhabitants of Chinantla," which latter signifies a spot enclosed by cane hedges or palisades. By extension, the common term for "village" was *chinamitl*, as they were usually protected by such light defenses. The Chinantecs, therefore, as a nation, are known to us only by the name applied by their neighbors, the Aztecs, to their chief town.